



Laser Cutting

Anders Ivarson

Laser Cutting

- ▶ Non-contact process, i.e. no clamping necessary
- ▶ Extremely narrow kerf width (0.1 to 1.0 mm)
- ▶ The process is fully CNC controlled
- ▶ Although laser cutting is a thermal process the HAZ is narrow
- ▶ High cutting speeds, e.g. 2 mm at 6 m/min (1200 W laser power output)
- ▶ Components ready for service immediately after cutting without any subsequent cleaning operation
- ▶ Reduced waste of material
- ▶ High capital cost – low running cost
- ▶ Quiet process compared to e.g. plasma cutting
- ▶ Safe process to use

2009-11-23

Knowledge Service Center

4

SSAB

Laser Cutting

▶ Factors that affects cut quality (laser and equipment):

- Output laser power
- Energy distribution of the laser beam
- Pressure of the cutting gas
 - Oxidation reaction
 - Mechanical force
- Oxygen purity
- Nozzle condition
- Cutting speed
- Focal point position
- CW or pulsed laser

Laser Cutting

For best result lasers cut at 80-90 % of the maximum speed.

Although parameters can be varied and still produce an acceptable cut edge quality

- Laser power: + 30% or – 10% is OK
- Focus position: Defocusing of ~ 1 % of the focal length is OK
- Sheet condition: Local areas of moderate surface corrosion is OK
- Oxygen supply: Variation in oxygen pressure with 10 % is OK
- Cutting speed: Between maximum cutting speed and 50 % of maximum cutting speed is normally OK

From these comments it is clear that laser cutting of mild steels is a reliable and rugged process

2009-11-23

Knowledge Service Center

5

SSAB

2009-11-23

Knowledge Service Center

6

SSAB

Laser Cutting

▶ Factors that affects cut quality (material):

- Surface quality
 - **Bright** (Cold reduced or Cold rolled): Degrease can interfere with the cutting process, although almost negligible.
 - **Black** (hot rolled): Mill scale might affect the cut quality if it is uneven and thick. Thin, even mill scale is most of the time not a problem
 - **Pickled and Oiled**: Not a problem
 - **Zinc Coated**: A thin galvanised surface usually presents no problems to the laser cutting process, some dross adhesion can occur. Hot dip galvanised has a thicker zinc layer that interfere with the cutting process.
 - **Paint**: Some paint can impede cutting
 - **Shot blasted**: Sand or ceramic beads used for shot blasting affects laser cutting due to the presence of Silica.
 - **Rust** (Corroded): Rust on the surface can cause problems to the cutting process

▶ Factors that affects cut quality (material):

- Alloying elements:
 - **Carbon**: Carbon dilutes the oxygen, i.e. reduced oxygen purity results in reduced heat input to the cutting process
 - **Silicon**: Silicon dilutes the oxygen, changes the surface tension of the melt in the cut zone
 - **Chromium**: Higher affinity to oxygen than Fe, i.e. changes the viscosity and surface tension of the melt in the cut zone.
 - **Nickel**: Changes the viscosity and surface tension of the melt in the cut zone
 - **Sulphur**: Sulphur reacts with oxygen (SO or SO₂) that dilutes the oxygen ⇒ reduced heat input ⇒ reduced cutting speed

2009-11-23

Knowledge Service Center

8

SSAB

2009-11-23

Knowledge Service Center

9

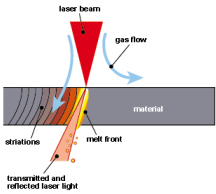
SSAB

Laser Cutting

- ▶ Troubleshooting:
 - Nozzle contamination
 - Laser Power
 - Cutting speed
 - Cutting gas type, pressure and/or flow rate
 - Nozzle material standoff
 - Nozzle type, condition and alignment
 - Material specification
 - Lens type, condition and alignment
 - Laser mode quality
 - External mirror condition and alignment

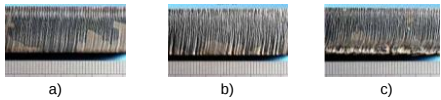
Laser Cutting

- ▶ Laser cutting principle
 - Oxygen gas laser cutting
 - Inert gas laser cutting (high pressure)



Laser Cutting

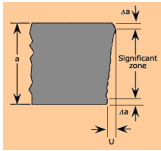
- ▶ Cut edge surface roughness:
 - R_a values of approximately 0.5 to 15 μm
 - R_z values of approximately 2 to 60 μm



12 mm thick mild steel. a) Cut with 0.8 m/min, b) cut with 0.9 m/min and c) cut with 1.0 m/min.
N.B. soft oxide layer on the cut edge.

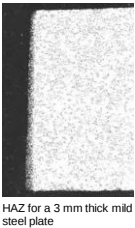
Laser Cutting

- ▶ Cut edge squareness in the order of 0 – 0.2 mm depending on material thickness and cutting speed.
 - Increased thickness increases U
 - Increased speed decreases U



Laser Cutting

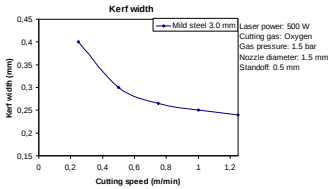
- ▶ Heat affected zone (HAZ)
 - Increased HAZ with decreased cutting speed
 - Increased HAZ with increased material thickness
 - Increased HAZ with increased heat input
- ▶ Typical HAZ is less than 0.5 mm



HAZ for a 3 mm thick mild steel plate

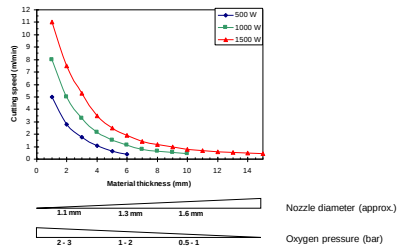
Laser Cutting

- ▶ Kerf width
 - As a general rule of thumb, the kerf width is less than 1.0 mm
 - Normally the kerf width is between 0.1 and 0.5 mm (depending on material thickness and cutting speed)



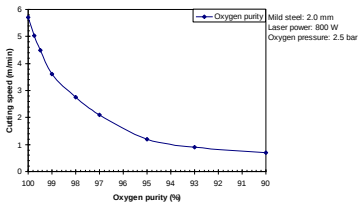
Laser Cutting

Cutting speed



Laser Cutting

Oxygen purity



Laser Cutting

Domex 4 mm

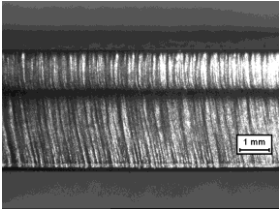
Laser Power: 4 kW
Oxygen Pressure: 0.8 bar
Nozzle material standoff: 1.5 mm
Material thickness: 4 mm

Material	Cutting speed (m/min)	Cut edge roughness (μm)		Edge squareness (mm)	HAZ (mm)
		Ra	Rz		
Domex 355	4.3	0.5	2.8	0.07	0.23
Domex 420	4.3	0.5	3.0	0.03	0.20
Domex 700	4.3	0.5	2.8	0.03	0.20

N.B. HAZ measured 2/3 from upper surface

Laser Cutting

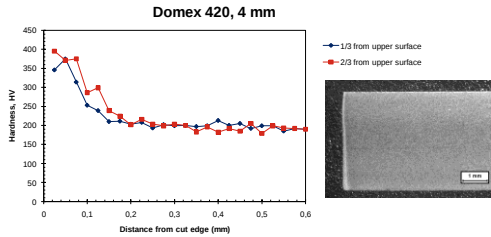
Surface finish, striations
– Domex 420, 4 mm



Ra = 0.5 μm
Rz = 3.0 μm

Laser Cutting

Heat affected zone



Laser Cutting

Domex 8 mm

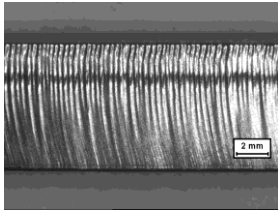
Laser Power: 4.8 kW
Oxygen Pressure: 0.7 bar
Nozzle material standoff: 1.5 mm
Material thickness: 8 mm

Material	Cutting speed (m/min)	Cut edge roughness (μm)		Edge squareness (mm)	HAZ (mm)
		Ra	Rz		
Domex 355	2.8	1.9	10.8	0.08	0.30
Domex 420	2.8	7.5	34.0	0.11	0.40
Domex 700	2.8	3.5	21.1	0.07	0.27

N.B. HAZ measured 2/3 from upper surface

Laser Cutting

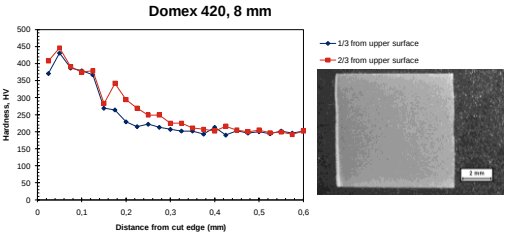
- Surface finish, striations
 - Domex 420, 8 mm



Ra = 7.5 µm
Rz = 34.0 µm

Laser Cutting

- Heat affected zone



Laser Cutting

- Domex 10 and 12 mm

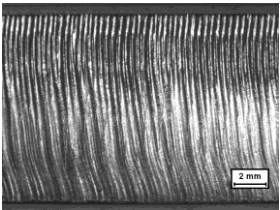
Laser Power: 4.8 kW
Oxygen Pressure: 0.7 bar
Nozzle material standoff: 1.5 mm
Material thickness: 10 and 12 mm

Material	Cutting speed (m/min)	Cut edge roughness (µm)		Edge squareness (mm)	HAZ (mm)
		Ra	Rz		
Domex 355 (12 mm)	1.9	10.6	50.0	0.06	0.52
Domex 420 (12 mm)	1.9	14.2	63.2	0.11	0.50
Domex 700 (10 mm)	2.4	8.8	44.4	0.06	0.35

N.B. HAZ measured 2/3 from upper surface

Laser Cutting

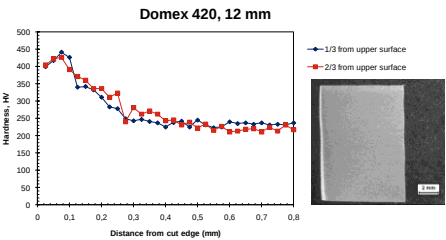
- Surface finish, striations
 - Domex 420, 12 mm



Ra = 14.2 µm
Rz = 63.3 µm

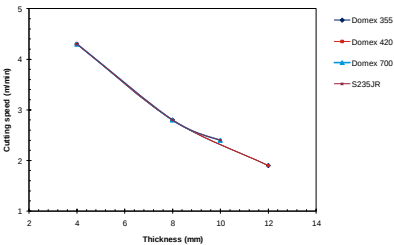
Laser Cutting

- Heat affected zone



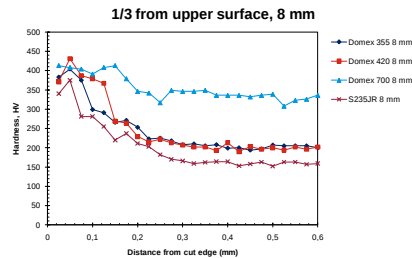
Laser Cutting

- Cutting speed



Laser Cutting

► Heat affected zone



Laser Cutting

► Domex 960

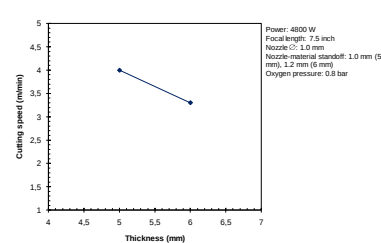
Laser power: 4800 W
Lens focal length: 7.5 inch (190 mm)
Nozzle diameter: 1.0 mm
Nozzle material standoff: 1.0 mm (5 mm) and 1.2 mm (6 mm)
Oxygen pressure: 0.8 bar

Thickness (mm)	Cutting speed (m/min)	Cut edge roughness (μm)		Edge squareness (mm)	HAZ (mm)
		Ra	Rz		
5	4.0	2.37	10.45	0.076	0.5
6	3.3	3.38	15.23	0.086	0.5

N.B. HAZ measured 2/3 from upper surface

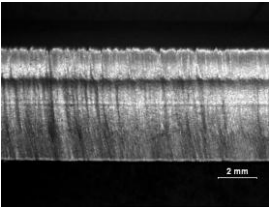
Laser Cutting

► Domex 960, Cutting speed



Laser Cutting

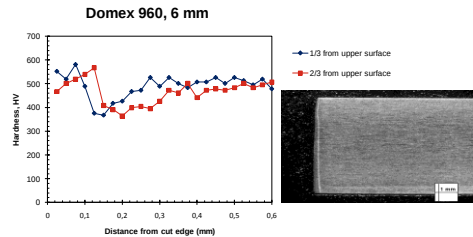
► Domex 960, 6 mm – Surface finish, striations



Ra = 3.38 μm
Rz = 15.23 μm

Laser Cutting

► Heat affected zone



Laser Cutting

► Domex 1200

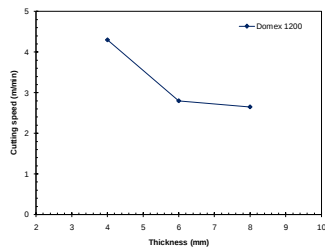
Laser Power: 3.5 kW (4 mm), 4.6 kW (6 mm) and 4.8 kW (8mm)
Oxygen pressure: 0.8 bar (4 and 6 mm), 0.7 bar (8mm)
Nozzle material standoff: 0.7 mm (4 mm), 1.1 mm (6 mm) and 1.5 mm (8 mm)
Material thickness: 4, 6 and 8 mm

Thickness (mm)	Cutting speed (m/min)	Cut edge roughness (μm)		Edge squareness (mm)	HAZ (mm)
		Ra	Rz		
4	4.3	1.4	7.9	0.03	0.40
6	2.8	2.2	11.4	0.02	0.50
8	2.65	2.2	11.7	0.05	0.60

N.B. HAZ measured 2/3 from upper surface

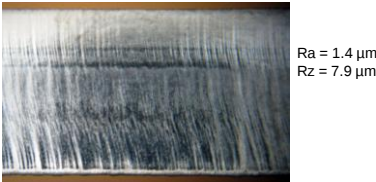
Laser Cutting

► Cutting speed, Domex 1200



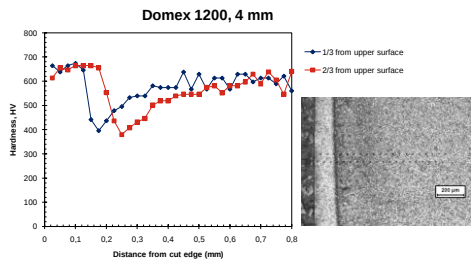
Laser Cutting

► Surface finish, striations
– Domex 1200, 4 mm



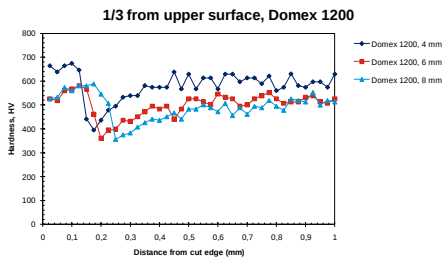
Laser Cutting

► Heat affected zone



Laser Cutting

► Heat affected zone



Laser Cutting

► Domex Wear 400

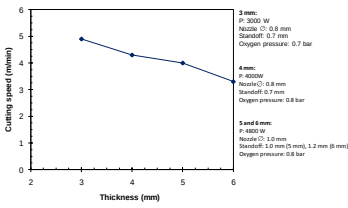
Laser power: 3000 W (3 mm), 4000 W (4 mm) and 4800 W (5 and 6 mm)
Lens focal length: 7.5 inch (190 mm)
Nozzle diameter: 0.8 mm (3 and 4 mm), 1.0 mm (5 and 6 mm)
Nozzle material standoff: 0.7 mm (3 and 4 mm), 1.0 mm (5 mm) and 1.2 mm (6 mm)
Process gas: Oxygen
Oxygen pressure: 0.7 bar (3 mm) and 0.8 bar (4, 5 and 6 mm)

Thickness (mm)	Cutting speed (m/min)	Cut edge roughness (µm)		Edge squareness (mm)	HAZ (mm)
		Ra	Rz		
3	4.9	1.11	6.49	0.067	0.22
4	4.3	0.73	4.32	0.081	0.25
5	4.0	1.59	7.48	0.042	0.35
6	3.3	1.28	7.55	0.068	0.40

N.B. HAZ measured 2/3 from upper surface

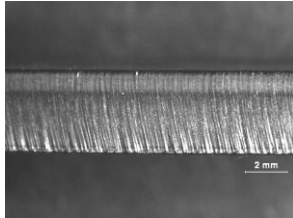
Laser Cutting

► Domex Wear 400, Cutting speed



Laser Cutting

- Domex Wear 400, 4 mm
 - Surface finish, striations



$R_a = 0.73 \mu\text{m}$
 $R_z = 4.32 \mu\text{m}$

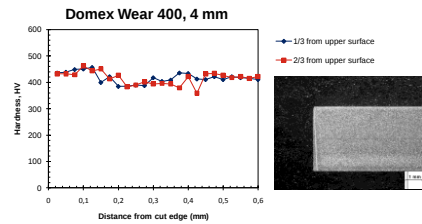
2009-11-23 Knowledge Service Center

43

SSAB

Laser Cutting

- Heat affected zone



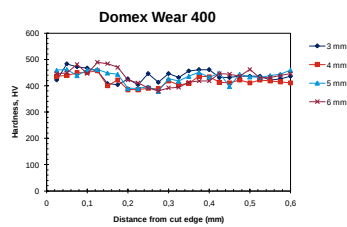
2009-11-23 Knowledge Service Center

44

SSAB

Laser Cutting

- Heat affected zone



2009-11-23 Knowledge Service Center

45

SSAB

Laser Cutting

- Laser cutting of Domex steels:
 - High cutting speeds
 - Narrow HAZ
 - Very good cut edge quality
 - Very good cut edge squareness
- Lean chemical composition
- SSAB do not have a specific laser cut quality – We don't need to!!!

2009-11-23 Knowledge Service Center

46

SSAB

